SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE COMPLEX

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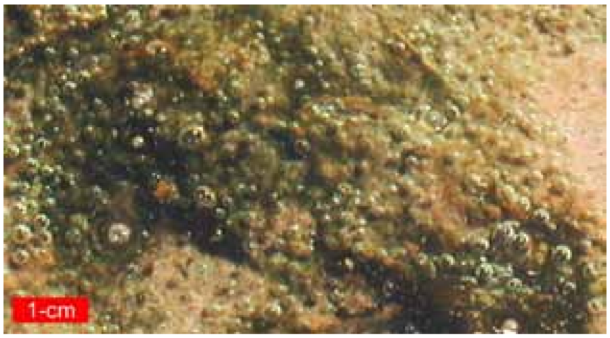
# Tideline

Don Edwards / Antioch Dunes / Ellicott Slough / Farallon Island / Marin Islands / Salinas River / San Pablo Bay

## Salt Marsh Life at the Bottom of the Food Chain

*By Wayne Lanier*

Look in any shallow salt marsh pond on a sunny day and you will see the foundation of life at the bottom of the food chain. A blue-green mat may cover the mud of the pond; or perhaps a yellow fuzzy mat may coat the stems of pickleweed growing in the water; or a thick green, yellow, red, or even multicolored mat may float on the surface of the pond.




*Cyanobacterial Mat*
*Photo by Wayne Lanier*

These colorful mats support a multitude of different microorganisms, collectively called "plankton." Each microbial mat is characterized by one or more dominant species of bacteria or diatoms. Such mats are often mistakenly called "algae," although algae is rarely the dominant species in a salt marsh mat.

Microbial mats constitute one of the most diverse and productive ecologies on earth.

Microbial mats are diverse because the number of species in a typical mat is enormous. Consider all the species of salt marsh life that you can easily see: the birds; the animals; and, the marsh plants. At a stretch, this might number 100 species. The number of species of microbial life in the microbial mat of a salt marsh pond, as measured in DNA samples, exceeds 5,000 species.

Microbial mats are productive because they produce enormous quantities of oxygen and take up enormous quantities of carbon dioxide. Almost all the green and red bacteria are *photosynthetic* as are the diatoms and the algae. This means they use the energy from the sun to fix carbon dioxide into the chemicals of life, while releasing oxygen.

If the microbial mat is submerged, it is likely to be covered with very many tiny bubbles. These bubbles are almost pure oxygen, released during photosynthesis. Surface tension keeps them attached to the mat until their size becomes great enough that their buoyancy detaches them and floats them to the surface. Counting the bubbles in a measured area and calculating their volume provides a minimum estimate of the amount of oxygen produced in a day. A 10-ft x 10-ft area of salt marsh microbial mat *minimally* produces *per* day as much oxygen as a large hardwood tree with a trunk more than one foot in diameter with a typical canopy more than 30 feet in diameter.

In addition to diversity and productivity, the biomass bound up in the microbial mat and in the microbes in the salt marsh mud exceeds that of all the other life in

*Courtesy of Pelican Media*

the salt marsh by 1,000-times. This makes sense, for salt marsh microbes are at the bottom of the food chain and *must support all the other life*.

Typically, the first step up the food chain is composed of the protozoa that live in and graze the microbial mat. Above them are the zooplankton, mostly the larvae of insects and marine organisms, such as mollusks.

When you see an Avocet sweeping the bottom of the pond or mud flat with its curved beak, it is sweeping up microorganisms from the mat, zooplankton, and the mollusks and worms that live in the mud. When you see a Clapper Rail pecking into the mud flat, it is feeding on mollusks that filter-feed on plankton that depend on the microbial mat. All of these steps in the food chain are vital for a healthy salt marsh, and it all begins *with the microbial life at the*

continued next page

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*bottom of the food chain*.

Not only does the microbial mat support the food chain, it also purifies the salt marsh water by sequestering and removing the pollutants so that the other dwellers of the salt marsh can survive. The first stage in recovery of a damaged salt marsh is recovery of the microbial mat.

Microbial mats form in all salt marsh waters, from tidally-washed mud flats to deep salt ponds. The richest microbial mat communities form, however, in shallow ponds with tidal inlets above the *mean high tide*. Such shallow ponds are the most productive because the mat-forming microbial community is photosynthetic and less sunlight reaches the bottom of deep ponds. Ponds with tidal inlets at and above the mean high tide are most rich in species because such ponds are not washed by every tide, as is a mud flat, but are only tidally washed at irregular intervals of days or even weeks.

Every one of the many species in the microbial mat has a salinity at which it grows best. Below and above that salinity, growth diminishes, so the growth curve is shaped like a hill. Most algae grow fast in fresh or brackish water; most large bacteria and diatoms grow fast in water at or above the Bay salinity. Dinoflagellates grow at even higher salinities and Halobacteria only reach maximum growth at about 5-times the salinity of seawater.

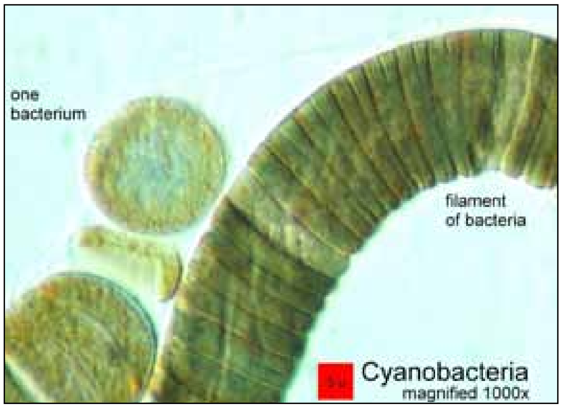
Salinity is measured by the number of grams of salt in each liter of water. Since a liter of water weighs a thousand grams, this expressed as parts of salt *per* thousand water [PPT]. San Francisco Bay water averages a little below 35 PPT salinity.

Every time a salt marsh pond is washed by the tide, its salinity is reset to the Bay salinity. If it is not washed again for several days, evaporation causes the salinity in the remaining water to rise. Depending upon its elevation above the mean tide, a salt marsh pond is tidally washed from once every day or so, to once or twice per month. This causes the salinity to vary between 30 to 35 PPT after washing, to as much as 50 PPT after weeks of evaporation. Salinity in evaporative salt ponds exceeds 200 PPT, where any Halobacteria or Dinoflagellates may be swimming around salt crystals as the pond rapidly dries out.

As the ordinary salt marsh pond varies in salinity, each species in the microbial mat gets a time at the salinity of its optimum growth. These microbes have dormant states in which they can survive extremely unfavorable conditions. A salt marsh pond that varies widely in salinity will continue to support communities of very many species of microbe, each getting a brief time at optimum growth. This is why tidally-washed ponds are so rich in numbers of species. It is also one of the reasons why they are so productive in producing oxygen and taking up carbon dioxide.

The dynamics of salt marsh pond microbial communities are very complex and poorly understood. Not all microbes can form microbial mats. Among other requirements for mat formation is ability to either stick to a surface, or stick together while floating. Often microbial mat formers are filamentous.

Examples of filamentous mat formers are species of the Cyanobacterium *Oscillatoria*, which form dark green mats.




*Filament of Cyanobacteria*
*Photomicrograph by Wayne Lanier*

Another mat-former is the colonial diatom *Melosira*, which forms yellow or yellow-orange mats:


*Colonial Diatom*
*Photomicrograph by Wayne Lanier*

Many members of a mat community appear to engage in mutually beneficial relationships: One, perhaps, producing a growth pheromone required, while the other member provides shelter. These associations are very important in the microbial community, but are also poorly understood.

Although salt marsh microbial communities form the most important land ecosystems for producing oxygen and removing carbon dioxide from the atmosphere, they have been little studied until recently. In part this is because, traditionally, microbiologists have spent most of their efforts studying the 1-in-a-million microbial species that cause disease in humans. Only recently have microbiologists increasingly turned toward field microbiology.

Another reason for our limited knowledge is that microbes are much easier to study in the laboratory, but most ecologically important species do not grow well in the laboratory. Microorganisms are difficult to identify in field observations, requiring either culture or expensive DNA identification.

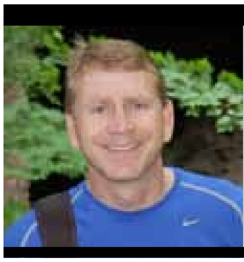
Finally, without the use of field microscopes, the novelty and beauty of these organisms are not easily recognized, and they are dismissed as "slime" or "smelly algae".

All of life is beautiful and interesting, for it is part of the great web that has uniquely shaped this planet for more than three billion years. That is especially true in the salt marsh, for many species in the mat and almost all species down in the mud were not only around 3 billion years ago, but they built our present oxygen atmosphere. We cannot conserve the salt marsh and we cannot restore the salt marsh without its essential microbial communities.

*Wayne Lanier, PhD in microbial genetics, spends his retirement studying microbial ecology in the San Francisco Bay salt marsh and in desert salt and alkaline lakes. He has been professor in university and medical school. He has also been Director of Research in several biotechnology companies; and a clinical studies consultant.*

**To see these microbial communities up close, go on a walk with Dr. Lanier on April 10 or April 11. See the activity section for details.**

# It is not all about the birds



## Refuge Reflections

*by Mendel Stewart*

As we develop plans for wetland restoration around the bay, we are occasionally reminded that a healthy San Francisco Bay ecosystem is much more than healthy bird populations. Fisheries are also important and should be considered when planning for habitat improvements to the San Francisco Bay. While we believe fisheries have been considered, this resource is often overshadowed due to the potential impact to some bird species that large scale marsh conversion could cause.

Wetland restoration in the San Francisco Bay Area involves restoring tidal flow to salt ponds that have been separated from the bay for decades, which has eliminated habitat for fish and other aquatic species. The reconnection of these areas to the tides, and the subsequent re-establishment of marsh that is expected to occur, will surely be beneficial to a host of aquatic species, from fish to benthic organisms. This reconnection with the bay will provide important nursery habitats for fish species such as steelhead trout, flounder and sturgeon. However, some bird species, such as Black-necked Stilts, American Avocets and Eared Grebes, among others, could be negatively affected if this conversion does not leave enough of the open water habitats they prefer.

We also recognize that some methods of restoration can have negative impacts on fisheries, particularly the migratory species mentioned above. When the installation of pipes or other narrow openings is necessary to restore tides to former salt ponds, for example, fish entrapment may occur. Once fish swim into these ponds through the small openings, it is often difficult for them to find their way out. Entrapped migratory fish cannot complete their reproductive cycle, which, in turn, affects populations. To minimize this, we developed plans that require the structures be closed during fish migration periods.

In addition, we monitor our ponds regularly, sampling for fish. This allows us to modify our management procedures if impacts are found. We also monitor many water quality parameters such as dissolved oxygen, salinity, temperature and biological oxygen demand within managed ponds to ensure that we are doing our best not to impact the bay from discharged water.

In cooperation with others agencies, we will conduct several research projects to determine the effectiveness of both the restoration efforts themselves and our management. One of those projects will look at the effects of restoration on fish species composition and health. To learn more about the fisheries work we are conducting as part of the South Bay Salt Pond Project and other science initiatives, visit www.southbayrestoration.org/science.

Don Edwards San Francisco Bay National Wildlife Refuge
Ravenswood Point, East Palo Alto

# Earth Day Cleanup

Saturday, April 17, 2010 • 8:30 a.m. – 11:30 a.m.

Help us protect wildlife and the environment while enjoying great Bay views!
Join us on our Annual Earth Day Cleanup at Ravenswood Point in East Palo Alto.

We'll supply latex gloves and trash bags.
Wear sturdy shoes, a hat, and sunscreen. Prepare to work hard and get dirty!
RESERVATIONS REQUIRED! Call 408-262-5513 x106 to sign up.
Minors must be accompanied by an adult. Space is limited to 50 people.